Male and Female Summer Interns in Engineering from 2007-2012

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Abstract

The purpose of this study was to ascertain the colleges and universities from which engineering interns were chosen for the Langley Aerospace Research Student Scholars (LARSS) internship program over a six year period. While the initial question was where the interns were from, information was also obtained on these colleges and universities' rankings with respect to female faculty in tenure/tenure-track positions as well as research expenditures according to the American Society for Engineering Education's (ASEE) 2012 Annual Report. The majority of interns were selected from 14 institutions. Eight of the institutions for female interns and 7 for male interns were also cited as having the largest percentages/numbers of female faculty according to ASEE data. In 10 of the 14 institutions for male interns and 9 of 14 for female interns, the institutions were cited as having some of the highest research expenditures. Last, data from ASEE's report on bachelor degrees awarded in 2011 was assessed with respect to the 21 institutions listed as having higher numbers of women in tenure/tenure-track positions. The majority of these institutions represented larger engineering programs with a sizeable number of engineering faculty. These 21institutions accounted for 24.4% of the total engineering bachelor degrees awarded in 2011, with 27.4% of all female and 23.8% of all male graduates in the U.S.

Introduction

There is no doubt that well-trained engineers are needed in order for the U.S. to remain competitive in the international market place (Carnevale, 2011; Ohland et al., 2008; Pelton, Johnson & Flournoy, 2004). Data also suggests that the U.S. is losing vital resources by the low numbers of women and minorities who are choosing engineering as a career (ASEE, 2012; Fouad & Singh, 2011). A report by the Navel STEM Forum (2011) notes the most severe migration out of STEM majors is for women and minorities. Engineering is unique among college majors in that the majority of their graduates come from freshman entering college with engineering as their intended major (Ohland et al., 2008). For engineering, it is important to attract and retain entering students, especially women and minorities. If engineering programs lose students to other majors, they are unable to replenish their numbers by attracting other college students as is typical of most majors.

Business and industry have also expressed concern over the low numbers of students going into STEM fields. Adkins (2012), Senior Vice-President of IBM's Systems and Technology, proposed a three prong approach in trying to address the shortage. It was no surprise that he stressed increasing the size of the STEM education pipeline by encouraging and maintaining enthusiasm for STEM fields through high school and college. His second recommendation focused on increasing the representation of women and minorities in these fields. Third, he emphasized the need for role models who can inspire students to pursue STEM. He noted that currently only 5% of U.S. workers are employed in the science and engineering fields, but they are responsible for more than 50% of the country's sustained economic expansion. It is necessary for the U.S. to attract and retain more talented young people in STEM fields in order to remain competitive in the world marketplace.

As noted by Adkins (2012), one way to increase the STEM workforce is to increase the representation of women in STEM fields. Research by Sonnert, Fox and Adkins (2007) found that having same sex faculty role models had a small but significant effect in attracting and retaining women in STEM fields. In a longitudinal analysis from 1984-2000, it was found that institutions with higher numbers of women faculty in STEM areas were more likely to attract and retain female majors. As noted by Xie and Shauman (2003), STEM fields can be considered unique in that the undergraduate level is the last point of entry into these fields. If women are not engaged in STEM disciplines at the undergraduate level, they will not likely enter them at all.

The current study assessed higher education institutions from which a nationally recognized summer internship program selected student interns from 2007 through 2012. Of particular interest were the institutions from where female student interns in engineering were selected. It has been posited that having same-sex role models in a career field plays an important role in both attracting and retaining students (Fouad & Singh, 2011; Sonnert et al., 2007). Based upon this premise, the study sought to determine if female student interns were coming from institutions with higher percentages/numbers of female faculty. Student intern selection data was also assessed in regard to institutions with high research expenditures. In addition, the study explored what a national data base revealed about faculty and student gender representation for the 21institutions cited by ASEE as having the largest numbers of female faculty. Data regarding female faculty and research expenditures was obtained from ASEE's annual report (ASEE, 2012).

Method

Participants

Participants in this study were 492 (388 men and 104 women) engineering students engaged in a 10-week summer internship program. The internship program accepted interns in a wide variety of STEM fields, but engineering was the primary focus. For the purpose of this study, only college interns who specified engineering as their major were included. Data was available over the six year period from 2007 through 2012. While men were more evenly distributed across junior, senior and graduate school with each level showing a larger percentage, women showed the largest representation at the senior level. College students from around the country were chosen based upon their applications and mentoring opportunities to participate in this summer program. Of those selected to participate in the engineering internship over this six year time span 4 indicated race/ethnicity as Native American, 28 African American, 4 Pacific Islander, 43

Asian American, 39 Hispanic/Latino, 310 Caucasian, 23 other and 41 did not indicate their race/ethnicity. Table 1 presents information on race/ethnicity by gender as well as the percentage of either male or female interns and percentage of the total.

Table 1
Ethnicity/Race and College Classification by Student Interns Gender (n=492)

	Male Interns			Female Interns		
	Number	% of Men	%of Total	Number	% of Women	%of Total
Race/Ethnicity						
Native American	2	0.5%	<1%	2	1.9%	<1%
African American	21	5.4%	4.3%	7	6.7%	1.4%
Pacific Islander	4	1.0%	<1%	0	0.0%	0.0%
Asian American	34	8.8%	6.9%	9	8.7%	1.8%
Hispanic/Latino	33	8.5%	6.7%	6	5.8%	1.2%
Caucasian	247	63.7%	50.2%	70	67.3%	14.2%
Other	19	4.9%	3.9%	4	3.8%	<1%
Not Indicated	28	7.2%	5.7%	6	5.8%	1.2%
Classification						
Freshman	3	0.8%	0.6%	0	0.0%	0.0%
Sophomore	15	3.9%	3.1%	9	8.7%	1.8%
Junior	103	26.5%	20.9%	29	27.9%	5.9%
Senior	129	33.2%	26.2%	45	43.3%	9.1%
Graduate Student	138	35.6%	28.1%	21	20.2%	4.3%

LARSS Internship Program

The Langley Aerospace Research Student Scholars (LARSS) program is a nationally recognized internship program, and students are chosen from around the country based upon their applications and mentoring opportunities. The program is a year-round internship program with three sessions – fall, spring and summer. Fall and spring are 15 week sessions and summer is a 10 week session. The internship specific to this study is the 10-week summer program. The internship focuses on a range of specialty areas including: aeronautics; earth science research; exploration and flight; systems and concepts; systems engineering; subsonic/transonic testing; supersonic/hypersonic testing; and structures testing. While the primary focus of LARSS is engineering, other areas in science and technology are also open to select interns. The application for the internship is open to U.S. citizens and focuses on college/university students with a small number of talented high school students also being selected. For the purposes of this study only college/university engineering students were chosen. Scientists/researchers, the future mentors, select individuals from the pool of applicants to work on specific projects. As part of the internship, interns are required to write a technical paper and/or present their project at the end of the summer internship (a small number of exceptions may be made to this if the project is classified).

Goals of the internship experience focus on providing future professionals with opportunities to apply engineering and science concepts and principles to developing research-based solutions. Interns apply research methods, experimental designs and techniques, data analyses, and interpretation to research-based solutions. They also gain proficiency in presenting scientific and technical information via oral and written communication to peers and colleagues. The internship provides an opportunity for student interns to develop an appreciation for and the skills necessary to engage in life-long learning and to understanding the need to continually exploit those skills in refining and updating their knowledge base. One of the key components of the internship experience is to also learn to work and successfully function as a member of a group, team, or project composed of individuals with divergent backgrounds and life views. The internship experience provides the interns with opportunities to develop the skills needed to: (1) succeed as professional engineers and scientists; (2) fulfill their professional responsibilities; and (3) make sound ethical decisions.

Results

The major institutions from which engineering interns were chosen to participate in the LARSS summer internship program were identified for the period of 2007-2012. This timeline represents students who have in all likelihood recently completed their degree or are in the process of doing so. Next, these institutions were compared to ASEE's 2012 Profiles in Engineering list of colleges/universities with the highest percentage/number of women faculty in tenured/tenure-track positions. These comparisons are presented in Table 2.

Table 2
Engineering Programs for Student Interns by Gender from 2007-2012 with Largest Percentage and/or Number of Tenured/Tenure Track Female Faculty noted in bold

	Men			Women	
Institution	Number	Percent	Institution	Number	Percent
Virginia Tech	**34**	**8.8%**	**Virginia Tech**	**15**	**14.4%**
Old Dominion	29	7.5%	U of Virginia	8	7.7%
West Virginia U	17	4.4%	**MIT**	**5**	**4.8%**
NCSU	**17**	**4.4%**	Morgan State U	5	4.8%
U of Virginia	15	3.9%	Old Dominion	5	4.8%
Georgia Tech	**13**	**3.4%**	**Boise State U**	**4**	**3.8%**
Mississippi State U	8	2.1%	**Georgia Tech**	**3**	**2.9%**
U of Michigan	**7**	**1.8%**	**Penn State U**	**3**	**2.9%**
Penn State U	7	1.8%	**Purdue**	**2**	**1.9%**
MIT	**7**	**1.8%**	Rensselaer Poly	2	1.9%
U of Florida	**6**	**1.5%**	**Texas A&M**	**2**	**1.9%**
Morgan State U	6	1.5%	U of Minnesota	2	1.9%
U of Pennsylvania	5	1.3%	**Washington U**	**2**	**1.9%**
Thomas Nelson CC	5	1.3%	West Virginia U	2	1.9%
Subtotal	176	45.4%	Subtotal	60	57.7%

Note: Highlighted in **bold** are also the education institutions with the highest number and/or percentage of women tenured/tenure-track faculty based on ASEE's 2012 Profiles in Engineering (pg. 30).

Those colleges and universities with higher numbers and/or percentages of tenured/tenure track women faculty represented 7 of 14 top educational institutions for the selected male interns, and 8 out of 14 top educational institutions for the selected female interns. The next top schools/colleges of engineering for selected male interns were University of Delaware, University of Minnesota – Twin Cities, Utah State, Rutgers, Purdue, Embry-Riddle, and New Mexico Institute Mining and Technology with each institution having 4 student interns for 1% of the total each. For men there were 12 additional institutions with 3 student interns, 28 with 2 interns each and 92 with 1 intern over the period of 2007-2012. For women all the remaining schools (44) had 1 female intern for 1% of total each. The 14 institutions in Table 2 accounted for 45.4% of male interns and 57.7% of the female interns selected over a six year period of time.

Next, these 14 institutions were compared to ASEE's 2012 Profiles in Engineering list of schools/colleges of engineering with the highest research expenditures. Those schools with higher reported research expenditures represented 10 of 14 top education institutions for the selected male interns, and 9 out of 14 top education institutions for selected female interns. The data are presented in Table 3.

Table 3
Engineering Programs for Student Interns by Gender from 2007-2012 with Highest Research Expenditures noted in bold (n=492)

	Men			Women	
Institution	Number	Percent	Institution	Number	Percent
Virginia Tech	**34**	**8.8%**	**Virginia Tech**	**15**	**14.4%**
Old Dominion	29	7.5%	**U of Virginia**	**8**	**7.7%**
West Virginia U	17	4.4%	**MIT**	**5**	**4.8%**
NCSU	**17**	**4.4%**	Morgan State U	5	4.8%
U of Virginia	**15**	**3.9%**	Old Dominion	5	4.8%
Georgia Tech	**13**	**3.4%**	Boise State U	4	3.8%
Mississippi State U	**8**	**2.1%**	**Georgia Tech**	**3**	**2.9%**
U of Michigan	**7**	**1.8%**	**Penn State U**	**3**	**2.9%**
Penn State U	**7**	**1.8%**	**Purdue**	**2**	**1.9%**
MIT	**7**	**1.8%**	Rensselaer Poly	2	1.9%
U of Florida	**6**	**1.5%**	**Texas A&M**	**2**	**1.9%**
Morgan State U	6	1.5%	**U of Minnesota**	**2**	**1.9%**
U of Pennsylvania	**5**	**1.3%**	**Washington U**	**2**	**1.9%**
Thomas Nelson CC	5	1.3%	West Virginia U	2	1.9%

Note: Highlighted in **bold** are also the education institutions with the highest research expenditures (top 50 institutions) based on ASEE's 2012 Profiles in Engineering.

Of particular interest is the overlap of colleges and universities in Tables 2 and 3. Seven out of the 10 top research expenditure institutions for male interns were also rated as having higher

percentages/numbers of female faculty. For female interns, seven of the nine top research expenditure institutions were also rated as having higher percentages/numbers of female faculty.

Last, data from ASEE's report (2012) on bachelor degrees awarded in 2011 was assessed with respect to the 21 institutions listed in their annual report as having higher numbers of women in tenure/tenure-track positions. Data are presented in Table 4. The 21 institutions listed in Table 4 accounted for 27.4% of all the bachelor degrees awarded in the U. S. to women and 23.8% of those awarded to men in 2011. The percent of the graduating class composed of women varied widely from institution to institution ranging from a low of 13.4% to a high of 43.4% with an average of 20.7%. The majority of these institutions (14 out of 21) also represented larger universities with graduating classes in engineering above 800 in 2011. In terms of faculty, these 21 out of 343 institutions accounted for 26% of all female engineering tenure/tenure-track faculty and 24% of all engineering faculty.

Table 4
ASEE's Top 21 Colleges/Schools of Engineering for Number of Female Faculty in Tenured/Tenure Track Positions and Bachelor Degrees Awarded in 2011

Institution	**Male Graduates**	**Female Graduates**	**Total Graduates**	**% Female Grads of Total**	**% Male Grads of Total**	**No. Female Faculty**	**Total Faculty**	**% Female Faculty**
1 University of Michigan	**1,000**	**284**	**1,284**	**22.1**	**77.9**	**68**	**362**	**18.8%**
2 MIT	**377**	**289**	**666**	**43.4**	**56.6**	**62**	**371**	**16.7%**
3 Georgia Tech	**1,329**	**387**	**1,716**	**22.6**	**77.4**	**58**	**396**	**14.7%**
4 Penn State Univ	**1,255**	**195**	**1,450**	**13.4**	**86.6**	**54**	**353**	**15.3%**
5 Purdue	**1,124**	**270**	**1,394**	**19.4**	**80.6**	**49**	**315**	**15.6%**
6 Texas A&M Univ	**996**	**235**	**1,231**	**19.1**	**80.9**	**48**	**325**	**14.8%**
7 University of Washington	**609**	**192**	**801**	**24.0**	**76.0**	**47**	**228**	**20.6%**
8 Univ of Ill, Urbana-Champaign	1,125	257	1,382	18.6	81.4	43	385	11.2%
9 Virginia Tech	**1,054**	**216**	**1,270**	**17.0**	**83.0**	**39**	**331**	**11.8%**
10 North Carolina State Univ	**1,066**	**202**	**1,268**	**15.9**	**84.1**	**38**	**328**	**11.6%**
10 Northwestern Univ	245	101	346	29.2	70.8	38	188	20.2%
12 Ohio State Univ	847	144	991	14.5	85.5	37	265	14.0%
12 Univ of California, Davis	384	101	485	20.8	79.2	37	201	18.4%
14 Univ of Puerto Rico, Mayaguez	361	165	526	31.4	68.6	36	172	20.9%
15 Stanford	299	112	411	27.3	72.7	35	218	16.1%
16 Arizona State Univ	526	125	651	19.2	80.8	33	199	16.6%
17 Cornell	513	206	719	28.7	71.3	32	237	13.5%
17 Univ of Texas, Austin	812	219	1,031	21.2	78.8	32	266	12.0%
19 Iowa State Univ	719	136	855	15.9	84.1	30	221	13.6%
19 Univ of California, Berkeley	667	173	840	20.6	79.4	30	217	13.8%
19 Univ of Florida	**776**	**186**	**962**	**19.3**	**80.7**	**30**	**264**	**11.4%**
TOTAL	16,084	4,195	20,279	20.7	79.3	876	5,842	
NATIONALLY	67,710	15,291	8,3001	18.4	81.6	3,389	24,640	
% of Graduates from these Institutions in 2011			24.4	27.4	23.8			

Note: The institutions in bold are also cited as primary institutions from which student interns were selected in Tables 2 and 3. Also, the institutions above represent the highest number of female faculty and not highest percentage of female faculty in these engineering programs. Only Virginia Tech, University of Michigan, MIT and Washington University were listed as having highest percentage and number of female faculty in ASEE's 2011 report (pg. 30).

Discussion

There was a pattern in that a large portion of both male and female interns were selected from those institutions with greater representation of female faculty. While a direct cause-effect statement cannot be made from the simple comparisons in this study, the findings do support the need for further research. Sonnert et al. (2007) found a small but significant effect for the percentage of women faculty at a higher educational institution was predictive of the number of female majors. Fouad and Singh (2011) also cited the lack of adequate female role models as a factor in the number of women leaving engineering. The current study found a high number of female engineering students chosen over the last six years by a top ten nationally ranked internship site came from institutions with stronger female faculty representation. In addition, many of these same institutions were listed in the top schools/colleges of engineering from which male interns were selected.

The classification of college senior was the largest grouping for female interns. This indicated these are the young women who recently completed or will soon complete their undergraduate degree. They represented those women who persisted in their engineering major and have entered, or soon will enter, the workforce. Not only have many of these young women had female role models at their institutions, they have also engaged in an internship experience. As noted by Fouad and Singh (2011), the field of engineering loses many young female engineers after they complete their degrees. They found that 15% of women graduating with an engineering degree never entered the workforce in the area of their major. Of those women who never entered the workforce in engineering, "…the majority (n=267, 48%) graduated between the years 2000-2010" (pg. 18). Suresh (2011) mirrored similar concerns in his address to the President's Council of Advisors on Science and Technology noting a steady decline in women who obtain an undergraduate degree going on to a graduate degree and subsequently entering the workforce in STEM. He reported that even though women now represent close to 20% of engineering graduates, only 11% of professional engineers are women. There are many benefits to a well-developed internship experience (Pinelli & Hall, 2012), and more research is needed to ascertain if participating in an internship will reduce the number of women engineers who choose either not to enter the workforce in their field or leave after a few years.

The current study represents one snapshot in time, and no causal statements can be made based upon the data presented. This study addresses only one internship site over a six year period, and any generalizations should be made with caution. While the LARSS program has stressed representation in the internship by women and minorities since its inception, the representation of women and minorities remains limited and mirrors the national concerns of attracting and retaining talented individuals into engineering. The data support the need for further research looking at factors that may enhance not only the number of women but also minorities choosing engineering. One institution from the tables above in particular stood out in terms of women graduates. MIT's graduating class in 2011 was comprised of 377 men (56.6%) and 289 women (43.4%). Only one institution reported a higher percentage of female graduates – Franklin W. Olin College of Engineering with 44.9% of the BA degrees in engineering in 2011 being awarded to women (ASEE, 2012). Certainly MIT is doing something that is working to attract and retain women in engineering. While this one program stands out in terms of female graduates and women faculty representations, findings from the current study are also

discouraging in some respects. At the 21 institutions cited as having the highest number of female faculty, the range in representation is a low of 11.2% to a high of 20.9% of the entire engineering faculty at those institutions.

A large number of interns, both men and women, came from institutions reported by ASEE (2012) as having high research expenditures. There was an overlap between research expenditures and women faculty as well. Many factors play into an engineering program producing well-prepared and talented future engineers. Perhaps the institutions with both the research expenditures and higher numbers of female faculty are cognizant of the multiple factors that comprise a strong, competitive degree program and have worked to try and achieve a more equitable gender balance as well as providing research opportunities to students. Student interns were selected from a pool of applicants by their future mentors to work on specific projects with the financial support for the internship coming directly from the on-site researchers' project funds. Having applicants with prior research experience that institutional research monies can provide may enhance the consideration of those students. Findings also bring up the question as to how smaller programs with fewer resources can compete with larger institutions in providing this type of hands-on experience. While colleges/universities continue to face fiscal tightening, it is important that institutions work to develop opportunities for their students to engage activities where they can build and apply research skills. One option may be to build partnerships between business and industry and institutions of higher education (Pinelli & Hall, 2011; Schuurman, Pangborn, & McClintic, 2008).

The data in Table 4 citing institutions with high numbers of female faculty in tenure/tenure-track positions and the bachelor degrees awarded in 2011 (ASEE, 2012) is for one year in time. The numbers of female graduates need to be assessed over multiple time periods as well as attrition rates for female engineering majors at these institutions over multiple years. These 21 institutions awarded 24.4% of all the engineering bachelor degrees in the U.S. in 2011 (23.8% of all male graduates and 27.4% of all female graduates). Many of these institutions are also larger universities where not only are there more faculty positions thereby increasing the probability of having more female faculty, but they also have more applicants (male and female) due to the size of their programs. Larger institutions with more faculty have an advantage in external funding as well. By having more faculty, and especially if these institutions reward external funding, there will be more attempts to pursue external resources. By the sheer number of applications for external funding, there is an increased likelihood of succeeding thereby increasing research expenditures. In addition, many of these 21 universities have colleges/schools of engineering whereas smaller programs may be represented by departments of engineering. All of these factors should be taken into consideration when looking at the data in the current study and addressed in future research. What does stand out in striking detail is the fact that 15% is the overall average representation of women faculty at the 21 institutions reporting the largest numbers of female faculty. If the representation of female faculty is this low at those institutions with the highest reported numbers, then there is no question that much more needs to be done to address this level of gender inequity.

Future research needs to focus not only on same sex role models, but what role an internship experience may play in the career endeavors of former interns, especially women. Recent research by Cech, Rubineau, Silbey, and Seron (2011) debunked the ideas that women are less

likely to pursue field of engineering due to problems balancing a career and home or due to their self-assessments of lower abilities in math. Based on a four year study of female engineering students, they found women lacked the professional role confidence of their male counterparts. Internships may help transition women from college into the workplace by increasing professional role confidence. A longitudinal study of former LARSS interns is currently underway and hopefully a few of these questions put forth in this paper will be addressed.

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